A BENCHMARK FOR BEST VIEW SELECTION OF 3D OBJECTS

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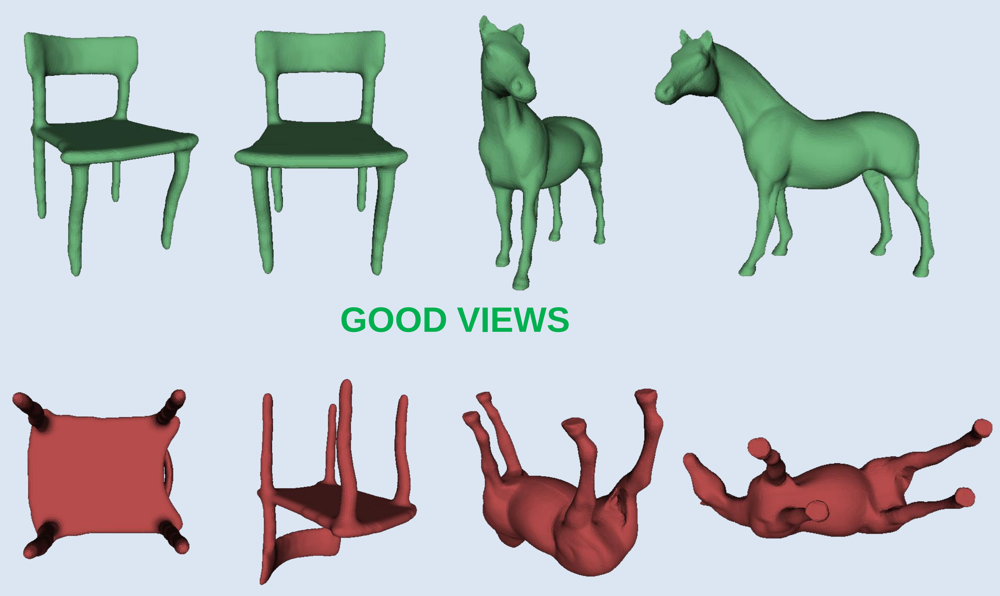
OBJECTIVE

BEST VIEW PROBLEM

- The problem corresponds to automatically selecting the most informative view of a model.
- Humans' judgement on good views is an important matter.



SOME APPLICATIONS:
- Thumbnail generation
- Automatic camera replacement
- 3D scene generation
- Surgery planning
- View based 3D object recognition

BEST VIEW SELECTİON ALGORITHMS

ALGORIHTMS ASSESSED IN THIS WORK

1) View area: The area of the projection of the object as seen from a particular viewpoint.

2) Ratio of visible area: Ratio of the visible surface area to the total surface area of the object.

3) Surface area entropy: In this method, the ratio of the projected area of a triangle to the total projected area of the object is assigned to be the "probability" of the triangle with respect to a particular viewpoint. The entropy over this probability distribution is the surface area entropy-based view descriptor.

4) Silhouette length: Length of the outer contour of the silhouette of the object as seen from a particular viewpoint.

5) Silhouette entropy: Entropy over the curvature distribution of the outer contour of the silhouette.

6) Curvature entropy: Entropy of the curvature distribution over the visible surface of the object.

7) Mesh saliency: The mean curvature at each vertex is weighted by two Gaussian filters one with scale twice the other. The absolute difference between the weighted curvatures at two scales corresponds to the mesh saliency at that scale pair. Then, the total mesh saliency at a vertex is calculated as the sum of mesh saliency values at successive scale pairs. The best view is selected as the one which maximizes the sum of saliency values at the visible vertices.

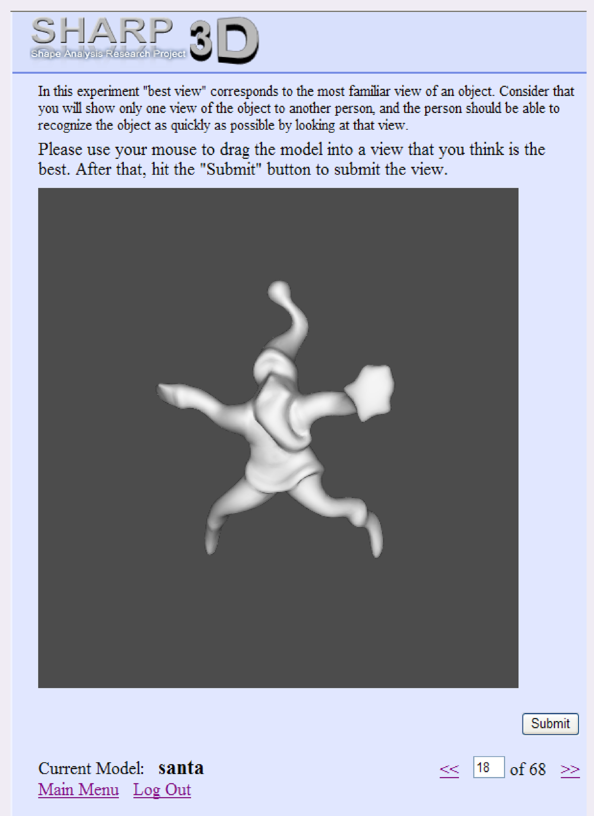
BENCHMARK DESIGN

3D MODEL DATASET

- 68 models in total
- Models widely used in 3D shape research (e.g. Armadillo, Dragon, Utah teapot, Bunny)
- Some models are from:
  - The Stanford 3D Scanning Repository
  - The SHREC2007 Watertight Model Database

Sample models from the dataset

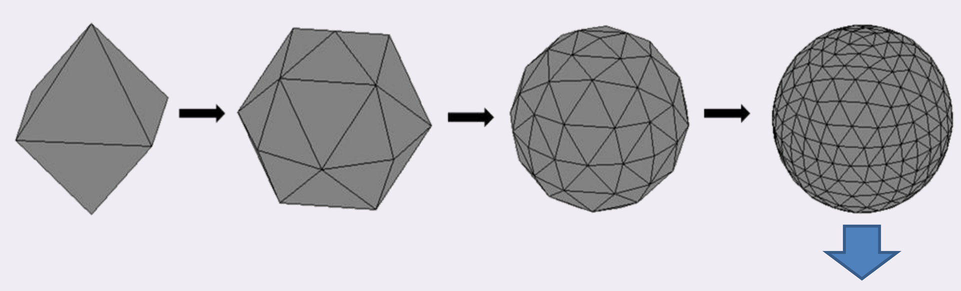
WEB-BASED USER INTERFACE FOR COLLECTING THE GROUND TRUTH



- Each model is initially rendered with a random pose.
- The user is asked to rotate the model via dragging the mouse into a view that he/ she thinks is the best, and then to click on the submit button.

VIEW SAMPLING

Starting from an octahedron, we iteratively subdivide the triangular mesh in order to get vertices on the sphere.



These vertices are used to sample the view sphere

$v \in V$ → set of viewpoints

258 VIEWPOINTS

SYMMETRICAL MODELS

m → model $\quad v$ → viewpoint

$$\Sigma_v = \{w \mid \underbrace{d(I_w, I_v)} \leq t,\ w \in V\}$$

Σ_v → Symmetry set

d: Rotation invariant dissimilarity measure between two views

I_w and I_v as seen from viewpoints w and v

t → threshold

GROUND TRUTH

s → user $\quad p_m^s$ → Viewpoint selected by user s

$$v_m^s = \arg\min_{v \in V} \underbrace{GD(p_m^s, v)}$$

v_m^s: Closest vertex on the geodesic sphere

$GD(p_m^s, v)$: Geodesic distance between vertex v and the viewpoint selected by user s

The ground truth supplied by user _s_ for a model _m_

$\Sigma_{v_m^s}$ → Symmetry set of v_m^s

EVALUATION MEASURE

Evaluate the success of the view selection algorithm with respect to the ground truth supplied by user *s* for a model *m*

a → View selection algorithm

$$W_s(v_m^a) = \min_v \frac{1}{\pi} \underbrace{GD(v, v_m^a)}, \quad v \in \Sigma_{v_m^s}$$

$W_s(v_m^a)$: Error from the human subject's choice

$GD(v, v_m^a)$: Geodesic distance between user selected viewpoint and viewpoint determined by the algorithm

View Selection Error

Average the error over all the users

$$VSE = \frac{1}{S}\sum_s W_s(v_m^a)$$

RESULTS

INCONSISTENCY

- We measure the inconsistency of the choices of the human subjects over a model in a similar way we calculate the performance of a view selection algorithm.
- We measure the distance of one subject's preference of view to another subject's preference.

$$W_p(v_m^r) = \min_v \frac{1}{\pi} \underbrace{GD(v, v_m^r)}, \quad v \in \Sigma_{v_m^p}$$

Geodesic distance between two viewpoints selected by users *p* and *r*

$$Inconsistency_m = \frac{1}{S^2}\sum_{p,r} W_p(v_m^r)$$

Table 1: Inconsistency values for some of the models

Models with low inconsistency		Models with high inconsistency	
bunny	0.107	camel	0.319
teddy	0.113	ant	0.329
cat	0.114	dog	0.330
cow	0.126	dragon	0.342
David's head	0.127	helicopter	0.391
vase	0.140	cup	0.392
human	0.149	octopus	0.395
Utah teapot	0.198	rockerarm	0.444
armadillo	0.212	hand	0.456

PERFORMANCE RESULTS

View Selection Error, averaged over the 68 models, of the seven automatic view selection algorithms

Table 2: Average View Selection Error of the view selection algorithms

View Selection Algorithm	VSE	n
View area	0.517	9
Ratio of visible area	0.473	7
Surface area entropy	0.396	15
Silhouette length	0.446	12
Silhouette entropy	0.484	7
Curvature entropy	0.474	9
Mesh saliency	0.430	9

● Human subjects, ● View area, ● Ratio of visible area, ● Surface area entropy,
● Silhouette length, ● Silhouette entropy, ● Curvature entropy, ● Mesh saliency

- Each model is rendered from side, front and bottom.
- The red dots are the viewpoints selected by the human subjects.
- Other points correspond to the viewpoints provided by the algorithms.
- The views selected by the algorithms are displayed in small images enclosed by the corresponding color.
- View Selection Error (VSE) is printed under the views.

CONCLUSION

- We introduced a benchmark that involves a methodology and a quantitative measure to evaluate the performance of view-selection algorithms.
- We conducted web-based subjective experiments to analyze humans' view preferences and to construct a ground-truth.
- We compared seven algorithms using the benchmark.